Direct Flame Impingement

A high-efficiency, rapid-heating, low-NO_x alternative to conventional steel shape heating

Sufficiently reheating shaped steel stock—such as strip, round or square shapes, and coil box transfer bars—requires rapid rates of heat transfer. Although large gas-fired radiation furnaces can perform such rapid heating, they are energy-intensive and generate high levels of NO_x emissions. The electric induction furnace is a common alternative because it rapidly heats material in a smaller space, but its operation incurs higher energy costs. Because reducing NO_x emissions and plant operating costs are key concerns for the U.S. steel industry, the aim of this project explores a third option: Direct Flame Impingement (DFI) technology.

During the DFI process, high velocity flame jets impinge upon the material being heated, creating a high heat transfer rate. As a result, refractory walls and exhaust gases are cooler, which increases thermal efficiency and lowers NO_x emissions. Because the jet nozzles are located a few inches from the load, furnace size can be reduced significantly. Additionally, high heat transfer rates and combustion product recirculation help to maintain load temperature uniformity and to minimize scaling.

In this project, researchers seek to use computation fluid dynamics modeling to determine the conditions that will make DFI technology implementation possible and to demonstrate the technology in both the lab and the field. The mature DFI technology is expected to achieve at least a 10-15% market penetration, representing 5.2 to 7.8 million tons of steel annually within five years after the conclusion of the field demonstration phase.

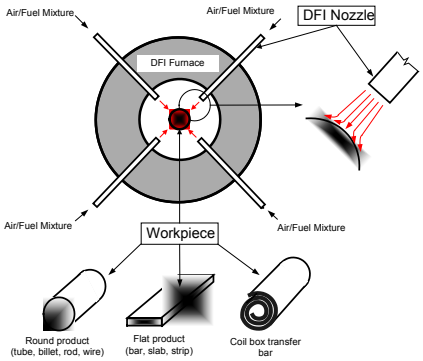

Figure: Schematic of DFI technology

Benefits for Our Industries and Our Nation

- Optimizes nozzle parameters such as DFI nozzle diameters, spacing, distances between nozzles and product surface, and the firing rate per unit area
- Achieves temperature uniformity of ±5° for strip and ±25° for rounds/squares
- Maintains necessary metallurgical properties
- Improves furnace efficiency of up to 20% over the base
- Increases productivity by up to 13% over the base
- Decreases NO_x emissions by up to 75% over the base

Project Participants:

Gas Technology Institute (Lead Organization)

Bricmont Inc.

Regional Ural Department of Academy of Engineering Sciences

ISG-Burns Harbor (now Mittal Steel)

The Timken Company

U.S. Steel

Gas Research Institute

GTI's Sustaining Membership Program

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PROJECT PLANS AND PROGRESS:

Work on this project has included:

- Developing and validating CFD models for the DFI process
- Developing a design for a DFI laboratory furnace and generating fabrication drawings
- Developing a set of matrices comparing the performance of DFI to conventional technologies
- Hosting a two-week visit by RUD AES to assist GTI with CFD model validation, DFI laboratory furnace design, and providing input to the comparison matrix
- Having the DFI laboratory furnace fabricated by North American Construction Services (NACS)
- Installing and instrumenting the DFI laboratory furnace
- Hosting a five-week visit by RUD AES to assist GTI in startup and initial operation of the laboratory furnace
- Conducting tests with the DFI laboratory furnace with various sized water-cooled round loads (calorimeters) and instrumented steel pipe, round tube, and round bar loads
- Conducting tests with different sized nozzles
- Conducting tests with flat loads (calorimeters) and instrumented steel plate loads
- Refining the design of a set of self recuperated nozzles
- Co-designing and fabricating a load-moving mechanism
- Meeting with a potential field sites (ISG-Cleveland; U.S. Steel Research Center-Pittsburgh; The Timken Company-Canton; Republic Engineered Products-Lackawanna; Chicago Heights Steel-Chicago Heights; CaluMetals-Chicago Heights)
- In discussion with Mittal Steel-East Chicago; NUCOR Steel-Seattle
- Developing a steel slab heating model to determine the effects of possible applications at the ISG-Cleveland site; and developing a steel tube heating model for the Timken site
- Initiating a feasibility study by North American Manufacturing Company at the ISG site to determine the best application for DFI at the site
- Developing a preliminary design concept for a field unit for the ISG site.
- Conducting tests in the DFI laboratory furnace with moving steel loads using the load oscillating mechanism received from NACS
- Assembling a test chamber and evaluated a self-recuperated DFI nozzle set
- Making site visits by GTI and Bricmont, Inc. to The Timken Company-Canton to visually observe and to evaluate heating applications at the site
- Analyzing two heating applications with DFI for Timken and selecting a hotpointing application for the field unit
- Executing a Field Test Agreement with Timken
- Developing a preliminary design for the DFI field unit for the Timken application

Future work will include:

- Completing engineering and drawings for the DFI field unit
- Fabricating the DFI field unit
- Operating and evaluating the DFI field unit
- Preparing a Final Technical Report

Steel Program

The Steel Industry of the Future (IOF) subprogram is based in the Industrial Technologies Program (ITP) within the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. The subprogram works with the steel industry to promote development of more energy-efficient and environmentally sound technology for steel processing. Guided by industry-identified research and development priorities, ITP's steel portfolio addresses those priorities that offer the greatest potential for energy savings in cokeless ironmaking, next-generaton steelmaking, and yield improvement. To learn more about Steel IOF activities, visit the program web site at: www.eere.energy.gov/industry/steel/

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Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

For more information contact:
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